Supporting Information

Riebesell et al. 10.1073/pnas.0813291106

SI Text

The following choices, assumptions, and simplifications were made in the marine CO_2 system calculations presented.

- We assume the annual increase in atmospheric CO_2 concentrations (xCO_2) to grow by 1% yr^{-1} starting with 2.0 parts per million by volume (ppmv) in 2008 and reaching 5.0 ppmv in 2100. This increase yields an atmospheric CO_2 concentration of 688 ppmv in 2100.
- Seawater total alkalinity (TA) was assumed to be insensitive to the uptake of anthropogenic CO_2 and thus not vary with time. For calculations shown in Fig. 1, the pCO_2 in surface seawaters was assumed to be always at equilibrium with atmospheric pCO_2, which was calculated by using the atmospheric CO_2 increase, a standard atmospheric pressure of 101.325 kPa, and the sea-surface temperature and salinity of the cold- and warm-water case, respectively. Both TA and pCO_2 were then used as givens in the sensitivity calculations.
- Calculations within the marine CO_2 system were made by using the carbonic acid dissociation constants of Mehrbach, et al. (1) as refitted by Dickson and Millero (2). Seawater pH is given on the seawater scale. We ignored the nonideality of CO_2 in air and used partial pressure (pCO_2) instead of fugacity of CO_2 (fCO_2), which is lower than the former by ≈0.3%. We furthermore ignored the contributions of phosphate and silicate to TA. These choices are not critical with respect to the features discussed and conclusions drawn here.
- For the cold- (and warm-) water case, the following choices were made: sea-surface temperature = 3° C (28° C), salinity = 34 (36), TA = 2275 μmol kg^{-1} (2,400 μmol kg^{-1}).
- In the Labrador Sea example, the extrapolation to year 2100 is based on the assumption that the observed annual mean pCO_2 disequilibrium (ΔpCO_2) remains the same. Further, the annual sea-surface temperature cycle is assumed to remain unchanged, as is the seasonal cycle of DIC anomalies. In essence, only the average surface-ocean-dissolved inorganic carbon is adjusted upward, such that the annual mean air–sea ΔpCO_2 is maintained. This may not be a very realistic assumption because both thermal and biological forcing as well as the average ΔpCO_2 will almost certainly respond to global change. However, for the illustrative purpose of our simplified calculation, we needed to reduce the degrees of freedom. In the real world, the ocean's potential response range will thus be even larger.

1. Mehrbach C, Culberson CH, Hawley JE, Pytkowicz RM (1973) Measurement of the apparent dissociation constants of carbonic acid in seawater at atmospheric pressure. *Limnol Oceanogr* 18:897–907.

2. Dickson AG, Millero FJ (1987) A comparison of the equilibrium constants for the dissociation constants of carbonic acid in seawater media. *Deep-Sea Res* 34:1733–1743.